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PHYSIOLOGICAL EVALUATION OF SOME FABA BEAN CULTIVARS UNDER WATER DEFICIT CONDITIONS

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ABSTRACT: A field experiment was conducted at El-Gemmeiza Agriculture Research Station, Elgharbia Governorate, Egypt, during the two successive Winter seasons 2017/2018 and 2018/2019 to evaluate four faba bean cultivars (Nubariya 2, Giza 716, Sakha 3 and Misr 1) under water deficit conditions. Water deficit was created by irrigating faba bean plants once only (I_1), compared to I_2, I_3 and I_4 irrigation treatments which received additional irrigation at 50, 65 and 80% of available soil moisture depleted, respectively. Water deficit (I_1) significantly decreased plant height, branch number plant^{-1}, leaf area index, dry matter plant^{-1}, crop growth rate, pod number plant^{-1}, seed number plant^{-1}, seed weight plant^{-1}, 100-seed weight, seed and straw yields fad^{-1} as well as total chlorophyll of leaves, whereas such treatment (I_1) significantly increased osmatic potential, water use efficiency, seed nitrogen and protein (%). In contrast, applying irrigation treatments (I_3) significantly increased all mentioned traits except osmatic potential, nitrogen and protein (%) of seeds which were decreased. Irrigation regime (I_3) increased pod number plant^{-1} seed number plant^{-1}, seed yield plant^{-1}, seed and straw yields fad^{-1} by 21.03, 14.36, 21.00, 26.46 and 27.54 (%), respectively but 100- seed weight increased by10.35% at (I_4) compared with irrigation regime (I_1). Each faba bean cultivar *i.e.* Nubaryia 2 and Giza 716 recorded the highest value for each of dry matter plant^{-1}, leaf area index, crop growth rate, branches number plant^{-1}, seed yield plant^{-1}, water consumptive use, water use efficient, total chlorophyll of leaves compared to the other two cultivars (Sakha 3 and Misr 1) but osmatic potential was decreased. In addition, Nubaryia 2 cultivar significantly surpassed the other cultivars (Giza 716, Sakha 3 and Misr 1) in plant height, 100- seed weight, nitrogen and protein (%) of seeds, while Giza 716 gave the highest value for each of pod number plant^{-1} and seed yield fad.$^{-1}$ than that of other cultivars but Misr 1 produced the lowest value of the previous traits. The interaction effect between irrigation regimes and faba bean cultivars was significant for all mentioned traits except branches number plant^{-1} and straw yield fad.$^{-1}$.The maximum values for each of LAI, DM, CGR, pod number plant^{-1}, seeds number plant^{-1}, seed yield fad.$^{-1}$, RWC and total chlorophyll of leaves were obtained when Giza 716 cultivar received irrigation regime (I_3), but Misr 1 recorded the lowest values for the same traits under irrigation regime (I_1). This work recommends sowing faba bean plants Nubaryia 2 cultivar with applying life irrigation only; such treatment (I_1) save about 29.38-34.76% of consumptive use (WCU) with accept reduction in seed yield about 11.11- 13.02 % if irrigation water was not enough and sowing Giza 716, Sakha 3 and Misr 1 in the presence of water abundance (I_3).

Key words: Faba bean, water deficit, cultivars, crop growth rate, total chlorophyll, water use efficiency, protein content.

INTRODUCTION

Average of faba bean crop in Egypt is about 40,000 hectare, it competes with the main Egyptian winter crops *i.e.* wheat and Egyptian clover (berseem). Faba beans, planted area declined from 45 thousand hectares to 35 thousand hectares between 2008 and 2015,

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which resulted in reducing total production from 160 to 120 thousand tons between the two mentioned years, *i.e.*, 25% decline in 2015 (**AEAS, 2016)**. Faba bean seeds are a good source of protein, fiber and nutritional value, and are widely grown for food and feed. Protein content in faba bean ranged from 24 – 35 % of the seed dry matter and is very rich in lysine. It is one of the main sources of cheap protein source for people in Middle East. Though the agronomic and economic importance of faba bean must be well studied, its cultivation is still limited due to its susceptibility to several biotic and abiotic stresses such as sensitivity to drought stress which considered a major factor that cause reduced yields. Drought severely affects plant biomass production **(Shao *et al*., 2008)** and modifies their morphological components through a decrease in plant height, leaf area, number of leaves and consequently plant biomass production. Furthermore, yield attributes such as seeds number and size were decreased (**Jaleel *et al*., 2008**). Water deficit causes a significant reduction in internode length, number and size of leaves, shoot dry matter, number of pods per plant and seed production (**Zabawi and Dennett, 2010**). Drought severely affects plant growth, seed yield and quality as well as caused morphological, physiological, biochemical, and molecular changes in plants (**Zarafshar *et al*., 2014**). **Ouji *et al*. (2017)** showed that drought affects the development, growth and yield components of faba bean plants, leading to a significant loss in productivity. Drought also affects many aspects of plant physiology, including dry weight plant^{-1}, leaf area plant^{-1}, net photosynthesis, relative water content, chlorophyll are reduced in faba bean (**Ammar *et al*., 2014; Siddiqui *et al*., 2015**). Moreover drought stress induced several physiological, biochemical and molecular disruptions on faba bean plant (**Abid *et al*. 2017**).

The reduction in faba bean seed yield was positively related to the amount of water reduction and reach up to 50% of seed yield (**Ammar *et al*., 2014; Afiah *et al*., 2016**). Water deficit in faba bean also caused a significant reduction in internode length, number and size of leaves, shoot dry matter, number of pods per plant and seed production those findings were noticed by **Zabawi and Dennett (2010**). **Dashadi *et al*. (2011)** reported that water deficit (irrigation after 75 mm evaporation from Class A pan) decreased number of pods plant^{-1}, number of seed pod^{-1}, 100-seed weight, seed yield (kg ha^{-1}), straw yield (kg ha^{-1}) and biological yield (kg ha^{-1}) compared with full irrigation. **Emam *et al*. (2010)** also reported that plant height, number of pods plant^{-1} of common bean were significantly decreased by water stress. In this connection, **Gupta *et al*. (2017)** found that irrigation level I_1 (APE, Accumulative Pan Evaporation =1.00) recorded maximum plant height, number of branches/plant, number of leaves/plant, leaf area/plant, number of pods/ plant, number of seeds/pod, pod yield/plant, pod yield/hr. and It was followed by I_2 (APE =0.75). Highest protein content was found under I_3 (APE = 0.50). WUE decreased with higher irrigation regimes (I_3) and was the lowest with I_1 (APE =1.00). **Pushpavalli *et al*. (2014)** reported that drought at any stage in the crop cycle can affect crop growth thus reducing grain yield, any water deficit during reproduction and seed filling (terminal drought) was more devastating. Reduction in fresh and dry weight of plant organs, leaf area and early maturity are key responses to mitigate the effect of drought on plants (**Farooq *et al*., 2009**). The maintenance of high net photosynthesis and the maintenance of relative water content are of the mechanisms by which drought-tolerant soybean genotypes counteract water deficit (**Hossaina *et al*., 2014**).

The response of plants to water deficit depends on genotypes, the length and severity of water deficit, and growth stages. **Mekkei (2014)** found that under drought stress, Giza 3 followed by Nubariya 1 cultivars gave the highest value for each of No. of pods plant^{-1}, 100- seed weight, seed yield plant^{-1}, seed yield fad^{-1} and seed protein content. However, Sakha 3 cv gave the lowest value of the such traits. **Belal *et al*. (2018)** recorded that the two faba bean cvs. Giza 843 and Giza 716 surpassed Misr 1 and Sakha 1 under drought stress in plant height, number of branches plant^{-1}, number of pods plant^{-1}, 100-seed weight, seed yield (kg ha^{-1}) and dry weight plant^{-1}. Moreover **Abdellatif *et al*. (2019)** found that the susceptibility tested cvs. for drought stresses and tolerance revealed that "Giza716" was tolerant cultivars while “Misr 1” and “Sakha 1” cvs. are sensitive.

MATERIALS AND METHODS

A field trail was conducted during the two successive growing seasons 2017/2018 and 2018/2019 at Gemmeiza Agricultural Research Station Gharbia Governorate, Egypt; to evaluate four faba bean cultivars under water deficit conditions. The Experimental site was Silt clay loam in texture (15.21% sand, 36.57% silt and 42.91% clay). The soil had an average pH 7.93, organic matter 1.78 %, available N 34 ppm, available P 8.4 ppm and available K 430 ppm, respectively.

The experiment was laid out in split plot design with four replicates. The main plots were occupied by irrigation treatments, whereas sub-plots contained the cultivars. Each sub-plot was 10.5 m^2 (3 x 3.5) and included 5 ridges, 3.0 m long and 70 cm apart.

The treatments were as follows:

1- Main plots were allotted for the irrigation treatments regardless irrigation at planting as follows:

1- One irrigation, 30 days after sowing (DAS) (I_1).

2- Two irrigations along faba bean growth stages, (I_1) plus one irrigation when 50 % of the available water was depleted (I_2).

3- Two irrigations along faba bean growth stages, (I_1) plus one irrigation when 65 % of the available water was depleted (I_3)

4- Two irrigations along faba bean growth stages, (I_1) plus one irrigation when 80 % of the available water was depleted (I_4)

Sub-plots were devoted to faba bean cultivars *i.e.* Nubariya 2, Giza 716, Sakha 3 and Misr 1.

Faba bean seeds were sown on 12/11/2017 and 8/11/2018 in hills 20 cm apart and all sub-plots were received the recommended dose of mono superphosphate (15.5 % P_2O_2) and potassium sulphate (48 % K_2O) at rate of 200 kg/fad., and 50 kg/fad., respectively. At 1st irrigation, 15 kg N/fad., was added in the form of ammonium sulphate (20.5% N) as a starter dose. Normal agricultural practices for faba bean production were done in both growing seasons at the proper time.

Physiological Traits

At 100 and 120 days after sowing (DAS), sample of five plants randomly uprooted from the outer two ridges of the four replications and then plants were separated into their components *i.e.* leaves, stem and pods which dried at 70 °C in a ventilated oven to a constant weight to determine the following traits:

1- Dry matter (DM) at 100 and 120 DAS (g/plant)

2- Leaf area index (LAI) at 100 and 120 DAS.

To calculate leaf area/plant a disks for twenty leaves equal 40.19 cm^2 [(0.8 cm)^2 x 3.14 x 20] were determine according to **Watson (1952)** as the following formula:

LA= 40.19 x dry weight of leaves per plant/dry weight of leaves disks

LAI = unit leaf area per plant/unit ground area occupied by plant

3- Crop Growth Rate (CGR) (100-120 DAS) (g/m^2/day).

The following formula was used to determine CGR according to **Watson (1952)**

$$CGR = W_2\text{-}W_1 / (T_2\text{-}T_1)$$

Where w_2 and w_1 are the dry weight of plants grown on land unit area (m^2) at T_2 and T_1 times, where T_2 and T_1 are 120 and 100 days after sowing (DAS)**.**

Yield and Yield Components

At harvest time ten guarded plants were randomly taken from central ridges in each sub-plot to determine: Plant height (cm), branch number plant^{-1}, pod number plant^{-1}, seed number plant^{-1} seed weight plant^{-1} (g), and 100-seed weight (g).

Seed yield (ardab/fad.) and straw yield (ton/ fad.) were calculated from central area (4.8 m^2) in each sub-plot to avoid the border effect, where ardab =155 kg and faddan = 4200 m^2.

Water Relation

Leaf relative water content (RWC, %)

RWC (%) was estimated according to (**Barris and Weatherley, 1962**) as follows:

Table 1. Monthly maximum and minimum air temperatures and relative humidity (%) at El-Gemmeiza Agric. Res. Stat. in 2017/2018 and 2018/2019 seasons

Month	2017/2018				2018/2019			
	Relative humidity (%)	Temperature ºC			Relative humidity (%)	Temperature ºC		
		Min	Max	Mean		Min	Max	Mean
November	61.99	12.53	24.70	18.62	59.22	13.04	25.15	19.10
December	68.02	10.42	21.24	15.83	69.41	11.52	20.81	16.17
January	67.93	8.86	19.73	14.30	65.22	9.73	17.25	13.49
February	60.49	10.26	23.15	16.71	62.15	11.36	25.85	18.61
March	44.19	12.08	29.27	20.68	42.66	13.05	27.36	20.21
April	43.42	14.18	31.39	22.79	41.09	14.67	32.51	23.59

*** Source:** Water Requirements and field Irrigation Research Department, SWERI, ARC, Egypt.

RWC % = (Fw- Dw)/ (Tw- Dw) X 100

Where Fw, Tw and Dw are fresh weight, turgid weight and dry weight, respectively.

Leaf osmotic potential (OP, bar)

OP was determined according to (**Gusev, 1960**).

Water consumptive use (WCU)

Soil samples were taken, using a regular auger, at planting time, just before irrigation, 48 hours after irrigation and at harvesting time for soil moisture determination. Duplicate of soil samples were taken from 0-20, 20-40 and 40-60cm depths and their moisture content was gravimetrically determined and presented in Table 2.

The following equation was used to calculate water consumptive use (WCU) **(Israelson and Hansen, 1962)** as follows:

$WCU\ (mm) = \theta_2 - \theta_1 / 100 \text{ X BD X D}$

Where, θ_1 and θ_2 are soil moisture (%) by weight just before and 48 hr after each irrigation, BD is the soil bulk density and D is the effective root zone, (600 mm).

It is worthy to mention that water table measurements showed that it was not shared in water consumed by faba bean plants.

Water use efficiency (WUE)

Was computed by dividing the weight of seed yield in kg per fad., by water consumptive use per fad., in m^3 (kg/m^3) according to **Pierre *et al.* (1965)**.

Chemical Composition

Total chlorophyll of leaves:

At 90 days after sowing, leaves samples were taken to determined total chlorophyll content of leaves (mg/m^2) according to (**Moran, 1982**).

Nitrogen and protein contents

Mature seeds for the two growing seasons were subjected to determine N and protein (%) according to **AOAC (1990)**.

The collected data, except WCU, were statistically analyzed according to **Snedecor and Cochran (1980)** and treatment means were compared using Lest Significant Difference (LSD) test at 0.05 level of probability **(Waller and Duncan, 1969)**. Bartlett test was done according to **Bartlett (1937)** to test the homogeneity of error variances. The test was not significant for all assessed traits, so, the two season's data were combined. The discussions of the results were carried out on basis of combined analysis for the two seasons.

Table 2. Some soil- water constant properties and bulk density of the experimental sites in 2017/2018 and 2018/2019 seasons.

Soil layer depth (cm)	Field capacity (%)		Wilting point (%)		Available water (%)		Bulk density (g cm^{-3})	
	2017	2018	2017	2018	2017	2018	2017	2018
00 - 20	44.56	43.87	23.45	23.25	21.11	20.62	1.21	1.19
20 - 40	40.85	40.03	21.50	21.11	19.35	18.92	1.28	1.29
40 - 60	37.54	36.93	19.73	19.52	17.81	17.41	1.31	1.32

RESULTS AND DISCUSSION

Growth and Growth Analysis

Effect of water deficit on plant height, branche number plant^{-1}, leaf area index, dry matter and crop growth rate

Results presented in Tables 3 and 4 reveal that water irrigation regimes treatment had a significant effect on plant height, branche number plant^{-1}, leaf area index (LAI) at 100 and 120 days, dry matter (DM) at the same periods and crop growth rate (CGR) (100-120 DAS). The maximum values of such traits were obtained when plants received irrigation regime (I_3) followed by irrigation regime I_2 whereas the minimum values of such traits were recorded when plants exposed to water deficit irrigation (I_1). **Hegab *et al*. (2014)** on faba bean found that increasing irrigation treatment from 60 to 100% of the ETo (Evapotranspiration) significantly increased plant height, leaf area index and dry matter. Water deficit caused reduction in the leaf area enlargement and photosynthetic capacity so reduced total dry matter and eventually CGR (**Hirasawa *et al*., 1998**) because the earliest response to the leaf water deficit is stomata closure, which limits CO_2 diffusion to chloroplasts and limits photosynthesis (**Cornic and Masacci 1996**). The leaf area index behaved the same trend of dry matter but it was decreased in the second sample which may due to leaf senescence or decreasing in leaf water content, which in turn reduces the turgor pressure in leaf cells, thereby inhibiting cell division and enlargement **(Gupta *et al*., 2017)** added that lower growth under higher irrigation regimes might have enhanced the photosynthesis resulting in more synthesis and accumulation of food material which in turn contributed to higher yield attributes and yield**.** These results are in agreement with **Gh**assem**i-Golezani *et al*. (2009) and Siddiqui *et al*. (2015).**

Faba bean cultivars behavior

Results in Tables 3 and 4 show significant differences among faba bean cultivars in plant height, branche number plant^{-1}, leaf area index (LAI), dry matter (DM) as well as crop growth rate (CGR) (100-120 DAS). Nubariya 2 cultivar produced the tallest plants followed by Giza 716 cultivar, while Misr 1 cultivar was the shortest one. Giza 716 and Nubaria 2 cultivars gave the maximum values for each of branche number, dry matter, leaf area index at 100 and 120 days after sowing and crop growth rate (CGR) in the same growth period. In contrary, Misr 1 cultivar scored the lowest values on all growth traits of cultivars under study. These results are confirmed by **Belal *et al.* (2018)** who recorded that the two faba bean cvs. Giza 843 and Giza 716 surpassed Misr 1 and Sakha 1 under drought stress in each of plant height, branches number plant^{-1}and hence dry weight plant^{-1}.

Table 3. Water deficit effect on plant height, branch number plant^{-1} and leaf area index (LAI) of four faba bean cultivars in 2017/2018 and 2018/2019 seasons

Irrigation regime	Cultivar	Plant height (cm)			Branch number plant^{-1}			LAI (100 DAS)			LAI (120 DAS)		
		2017/ 2018	2018/ 2019	Comb.	2017/ 2018	2018/ 2019	Comb.	2017/ 2018	2018/ 2019	Comb.	2017/ 2018	2018/ 2019	Comb.
I_1	Nubariya 2	100.20	104.30	102.25	4.45	4.81	4.63	4.58	5.15	4.87	3.30	4.09	3.70
	Giza 716	92.40	96.40	94.40	4.00	4.41	4.21	4.23	4.59	4.41	3.00	3.28	3.14
	Sakha 3	89.30	90.20	89.75	3.66	4.14	3.90	3.78	4.37	4.08	2.45	2.74	2.60
	Misr 1	80.00	84.10	82.05	3.02	3.41	3.22	3.06	3.52	3.29	1.81	2.25	2.03
Mean		90.48	93.75	92.15	3.78	4.19	3.99	3.91	4.41	4.16	2.64	3.09	2.87
I_2	Nubariya 2	113.2	115.60	114.40	4.65	5.04	4.85	4.89	5.33	5.11	4.25	4.48	4.36
	Giza 716	106.6	110.60	108.60	5.27	5.53	5.40	5.29	6.31	5.80	4.96	5.06	5.01
	Sakha 3	102.0	105.30	103.65	3.84	4.74	4.29	4.38	5.13	4.76	3.11	3.45	3.28
	Misr 1	96.50	97.50	97.00	3.41	3.79	3.60	4.13	4.19	4.16	2.48	2.85	2.66
Mean		104.58	107.25	105.91	4.29	4.78	4.54	4.67	5.24	4.96	3.70	3.96	3.83
I_3	Nubariya 2	120.70	122.80	121.75	4.99	5.22	5.11	5.57	5.85	5.71	4.55	4.67	4.61
	Giza 716	113.40	117.70	115.55	5.86	6.17	6.02	5.93	6.36	6.15	5.43	5.76	5.59
	Sakha 3	112.10	115.60	113.85	4.59	5.06	4.83	5.09	5.32	5.20	3.99	4.31	4.15
	Misr 1	103.10	107.00	105.05	3.78	4.02	3.90	4.37	4.40	4.39	2.78	2.83	2.81
Mean		112.33	115.78	114.04	4.81	5.12	4.96	5.24	5.48	5.36	4.19	4.39	4.29
I_4	Nubariya 2	105.30	109.60	107.45	4.66	4.91	4.79	4.74	5.89	5.32	3.45	4.12	3.78
	Giza 716	98.10	101.90	100.00	4.34	4.72	4.53	4.59	4.74	4.67	3.26	3.38	3.32
	Sakha 3	89.50	93.40	91.45	3.94	4.33	4.14	4.18	4.71	4.43	2.64	2.87	2.75
	Misr 1	86.30	89.10	87.70	3.31	3.66	3.49	3.57	3.73	3.65	2.28	2.46	2.37
Mean		94.80	98.50	96.65	4.06	4.41	4.24	4.27	4.77	4.52	2.91	3.21	3.06
General mean of cultivars	Nubariya 2	109.85	113.08	111.45	4.69	5.00	4.85	4.95	5.55	5.25	3.89	4.34	4.12
	Giza 716	102.63	106.65	104.60	4.87	5.21	5.04	5.01	5.50	5.26	4.16	4.37	4.27
	Sakha 3	98.23	101.13	99.65	4.01	4.57	4.29	4.36	4.88	4.62	3.05	3.34	3.20
	Misr 1	91.50	94.43	92.95	3.38	3.72	3.55	3.78	3.96	3.87	2.34	2.60	2.47
LSD 0.05	Irrigation	5.10	5.50	4.83	0.44	0.42	0.36	0.47	0.44	0.32	0.35	0.39	0.27
	cultivars	4.29	4.65	3.41	0.45	0.49	0.39	0.42	0.32	0.28	0.34	0.33	0.24
	Irri. X Cult.	8.60	9.30	7.52	NS	NS	NS	0.83	0.64	0.53	0.67	0.65	0.52

Table 4. Water deficit effect on dry matter (DM) and crop growth rate (CGR) of four faba bean cultivars in 2017/2018 and 2018/2019 seasons

Irrigation regime	Cultivar	DM (g plant^{-1})						CGR (g .m^{-2} day^{-1}) 100-120 DAS		
		100 DAS			120 DAS					
		2017/ 2018	2018/ 2019	Comb.	2017/ 2018	2018/ 2019	Comb.	2017/ 2018	2018/ 2019	Comb.
I_1	Nubariya 2	47.50	50.79	49.15	61.38	64.99	63.19	4.96	5.07	5.01
	Giza 716	42.29	46.55	44.42	55.31	60.37	57.84	4.65	4.93	4.79
	Sakha 3	36.85	43.47	40.16	47.56	55.10	51.33	3.82	4.15	3.99
	Misr 1	31.74	33.45	32.60	40.90	42.56	41.73	3.27	3.25	3.26
Mean		39.60	43.57	41.59	51.29	55.76	53.53	4.17	4.35	4.26
I_2	Nubariya 2	57.99	61.83	59.91	71.67	75.24	73.46	4.88	4.78	4.84
	Giza 716	67.78	68.28	68.03	80.97	83.70	82.34	4.71	5.51	5.11
	Sakha 3	52.66	55.67	54.17	65.98	69.81	67.90	4.76	5.05	4.90
	Misr 1	43.53	46.07	44.80	53.27	56.5	54.89	3.48	3.72	3.60
Mean		55.49	57.96	56.73	67.97	71.31	69.64	4.46	4.77	4.62
I_3	Nubariya 2	62.86	64.07	63.47	79.96	80.76	80.36	6.11	5.96	6.03
	Giza 716	69.25	70.27	69.76	87.09	88.51	87.80	6.37	6.51	6.44
	Sakha 3	58.16	60.57	59.37	73.65	76.68	75.17	5.53	5.75	5.64
	Misr 1	50.26	53.09	51.68	62.59	66.08	64.34	4.40	4.64	4.52
Mean		60.13	62.00	61.07	75.82	78.01	76.92	5.60	5.71	5.66
I_4	Nubariya 2	50.54	52.31	51.43	64.40	66.75	65.58	4.95	5.16	5.05
	Giza 716	47.68	49.22	48.45	61.23	63.13	62.18	4.88	4.97	4.90
	Sakha 3	40.79	44.49	42.64	53.24	57.88	55.56	4.45	4.78	4.61
	Misr 1	34.88	37.33	36.11	44.78	48.17	46.48	3.53	3.87	3.70
Mean		43.47	45.84	44.66	55.91	58.98	57.45	4.44	4.69	4.57
General mean of cultivars	Nubariya 2	54.72	57.25	55.99	69.35	71.94	70.65	5.22	5.24	5.23
	Giza 716	56.75	58.58	57.67	71.15	73.93	72.54	5.14	5.48	5.31
	Sakha 3	47.12	51.05	49.09	60.11	64.87	62.49	4.64	4.93	4.79
	Misr 1	40.10	42.49	41.30	50.39	53.33	51.86	3.67	3.87	3.77
LSD 0.05	Irrigation	2.83	3.18	2.66	2.39	3.51	2.26	0.63	0.59	0.42
	cultivars	2.29	2.63	2.18	2.54	3.08	2.63	0.48	0.50	0.37
	Irri. X Cult.	4.58	5.26	4.71	5.07	6.17	4.80	0.97	1.00	0.70

Effect of the interaction

From Tables 3 and 4 the interaction between water irrigation regime treatments and faba bean cultivars had a significant effect on plant height, LAI, DM and CGR. Under water deficit (I_1) Nubariya 2 cultivar achieved the maximum values for plant height, branch number plant^{-1}, LAI, DM at 100 and 120 days after sowing and crop growth rate (CGR) in the same growth period, while Misr 1 cultivar recorded the minimum value for each mentioned traits. However, under irrigation regime (I_3), Giza 716 faba bean cultivar gave the maximum value for each of LAI, DM and CGR while Misr 1 recorded the minimum values. So it could be concluded that Nubaria 2 faba bean cv. could have better ability to resist drought stress.

Yield and Yield Component

Effect of water deficit on pod number plant^{-1}, seed number plant^{-1}, seed weight plant^{-1}, 100-seed weight, seed and straw yields fad.$^{-1}$

Results in Tables 5 and 6 reveal that water irrigation regimes treatment had a significant effect on pod number plant^{-1}, seed number plant^{-1}, seed weight plant^{-1}, 100- seed weight, seed and straw yields fad^{-1}. Such characters significantly decreased when plants exposed to water deficit (I_1) whereas, irrigation regime (I_3) increased pod number plant^{-1} seed number plant^{-1}, seed weight plant^{-1}, seed and straw yields fad^{-1} by 21.03, 14.36, 21.00, 26.46 and 27.68 (%), respectively compared with irrigation regime (I_1) but 100-seed weight increased by 10.35 % at irrigation regime (I_4) compared with irrigation regime (I_1). These results due to that increasing soil moisture stress reduced faba bean growth which in turn affected yield components traits. In addition, water deficits imposed (I_1) during the reproductive development of dry beans can decrease the number of flowers, pods and number of seeds per pod abortion and can reduce final seed yield, this opinion accompanied with the effect on yield becomes severe because the young flowers and young pods are weaker sinks for assimilates in comparison with other plant organs **(Karamanos and Giménez, 1991)**. Therefore, the consequences of a possible shortage of assimilates at the initial stages of flowering and pod setting will be more severe on the reproductive organs, and it is the main cause for poor fruit setting and consequently low seed yield. On the other hand treated plants by (I_3) enhanced growth plants thereby improved yield attributes. These results are in line with those reported by **Hegab *et al*. (2014)** who found that increasing irrigation treatment from 60 to 100% of the ETo (Evapotranspiration) significantly increased seed and biological yields fad^{-1}. A higher water status throughout the growing season is necessary to maintain unimpaired crop growth and high economic yield**.** Also these results agree with **(Afiah *et al*., 2016; Ouji *et al*., 2017)**

Faba bean cultivars behavior

Concerning the difference among faba bean cultivars, it could be noticed that there was a significant difference in each of pod number plant^{-1}, seed number plant^{-1} seed weight plant^{-1}, 100- seed weight, seed and straw yields fad.$^{-1}$. Results in Tables 5 and 6 show that Giza 716 cultivar significantly surpassed other cultivars in pod number plant^{-1}, seed number plant^{-1} and seed yield ardab fad^{-1}. Likewise, Nubariya 2 cultivar significantly surpassed the other cvs. in 100- seed weight. In this connect, seed weight plant^{-1} and straw yield ton fad.$^{-1}$ of both genotypes Nubariya 2 and Giza 716 significantly surpassed the other two cultivars (Sakha 3 and Misr 1). Giza 716 cultivar significantly surpassed Misr 1 cultivar in pod number plant^{-1}, seed number and seed yield ardab/fad., by 25.82, 15.09 and 28.25%, respectively while Nubariya 2 cultivar significantly surpassed Misr 1 cultivar in seed weight plant^{-1} and 100- seed weight by 27.75 and 19.56%, respectively. These results are confirmed by **Belal *et al.* (2018)** who recorded that the two faba bean cvs. Giza 843 and Giza 716 surpassed Misr 1 and Sakha 1 under drought stress in each of pod number plant^{-1}, 100-seed weight and seed yield (kg/ha). Also**, Abdellatif *et al.* (2019)** found that the susceptibility test for drought stresses and tolerance revealed that faba bean cultivar "Giza716" was tolerant while “Misr1” and “Sakha1” cultivars were sensitive. **Mekkei (2014)** found that Giza 3 cultivar was more tolerant to skipping irrigation followed by Nubariya 1 cultivar however, Sakha 3 was more sensitive to drought stress.

Table 5. Water deficit effect on pod number plant^{-1}, seed number plant^{-1} and seed weight plant^{-1} of four faba bean cultivars in 2017/2018 and 2018/2019 seasons

Irrigation regime	Cultivar	Pod number plant^{-1}			Seed number plant^{-1}			Seed weight plant^{-1} (g)		
		2017/ 2018	2018/ 2019	Comb.	2017/ 2018	2018/ 2019	Comb.	2017/ 2018	2018/ 2019	Comb.
I_1	Nubariya 2	20.08	22.66	21.37	63.79	65.16	64.48	54.18	55.37	54.78
	Giza 716	18.47	19.80	19.14	67.23	69.58	68.41	53.88	56.13	55.01
	Sakha 3	15.78	18.78	17.28	61.56	60.83	61.20	44.51	45.06	44.79
	Misr 1	13.60	16.25	14.93	56.78	57.82	57.30	38.08	39.27	38.68
Mean		16.98	19.37	18.18	62.34	63.35	62.85	47.66	48.96	48.31
I_2	Nubariya 2	18.80	23.04	20.92	68.64	69.6	69.12	59.38	60.10	59.74
	Giza 716	23.65	25.25	24.45	70.24	72.15	71.20	58.41	61.44	59.93
	Sakha 3	17.33	20.91	19.12	64.52	67.35	65.94	50.22	51.49	50.86
	Misr 1	15.93	18.72	17.33	60.96	60.25	60.61	42.82	44.39	43.61
Mean		18.93	21.98	20.46	66.09	67.34	66.72	52.71	54.36	53.54
I_3	Nubariya 2	21.14	23.03	22.09	74.73	77.42	76.08	68.55	69.22	68.89
	Giza 716	26.24	27.77	27.01	77.85	80.34	79.10	67.38	68.55	67.97
	Sakha 3	23.96	22.12	23.04	69.66	72.31	70.99	56.75	58.71	57.73
	Misr 1	19.32	20.56	19.94	66.49	68.33	67.41	49.72	50.30	50.01
Mean		22.67	23.37	23.02	72.18	74.60	73.39	60.60	61.7	61.15
I_4	Nubariya 2	21.04	24.73	22.89	65.57	67.55	66.56	63.25	64.57	63.91
	Giza 716	20.33	22.79	21.56	69.98	70.88	70.43	61.93	62.44	62.19
	Sakha 3	16.93	19.89	18.41	62.68	64.53	63.61	51.84	52.97	52.41
	Misr 1	14.83	17.49	16.16	58.9	61.54	60.22	45.76	47.05	46.41
Mean		18.28	21.23	19.76	64.28	66.13	65.21	55.70	56.76	56.23
General mean of cultivars	Nubariya 2	20.27	23.37	21.82	68.18	69.93	69.06	61.34	62.32	61.83
	Giza 716	22.17	23.90	23.04	71.33	73.24	72.29	60.40	62.14	61.27
	Sakha 3	18.50	20.43	19.47	64.61	66.26	65.44	50.83	52.06	51.45
	Misr 1	15.92	18.26	17.09	60.78	61.99	61.39	44.10	45.25	44.68
LSD 0.05	Irrigation	0.82	1.37	1.15	3.43	3.68	2.95	2.53	2.61	2.18
	cultivars	1.05	1.43	1.20	2.22	2.40	1.87	2.50	2.56	2.01
	Irri. X Cult.	2.10	2.85	2.47	4.44	4.79	3.56	5.01	5.11	4.31

Table 6. Water deficit effect on 100-seed weight, seed and straw yields fad.$^{-1}$ of four faba bean cultivars in 2017/2018 and 2018/2019 seasons

Irrigation regime	Cultivar	100-seed weight (g)			Seed yield (ardab fad.$^{-1}$)			Straw yield (ton fad.$^{-1}$)		
		2017/ 2018	2018/ 2019	Comb.	2017/ 2018	2018/ 2019	Comb.	2017/ 2018	2018/ 2019	Comb.
I_1	Nubariya 2	85.88	86.51	86.20	9.90	10.17	10.04	2.98	3.15	3.07
	Giza 716	80.26	82.11	81.19	8.80	9.25	9.03	2.55	2.67	2.61
	Sakha 3	73.70	75.23	74.47	7.51	8.12	7.82	2.33	2.52	2.43
	Misr 1	66.19	68.96	67.58	6.69	7.14	6.92	2.07	2.21	2.14
Mean		76.51	78.20	77.36	8.23	8.67	8.45	2.48	2.64	2.56
I_2	Nubariya 2	87.56	87.79	87.68	10.23	11.04	10.64	3.25	3.42	3.34
	Giza 716	83.05	84.74	83.90	12.04	12.80	12.42	3.66	3.97	3.82
	Sakha 3	78.72	80.91	79.82	9.47	10.09	9.78	2.80	3.13	2.97
	Misr 1	70.66	72.77	71.72	8.66	8.80	8.73	2.68	2.73	2.71
Mean		80.00	81.55	80.78	10.10	10.68	10.39	3.10	3.31	3.21
I_3	Nubariya 2	90.25	90.13	90.19	11.90	11.87	11.89	3.69	3.84	3.77
	Giza 716	85.12	86.57	85.85	13.33	14.01	13.67	3.98	4.29	4.14
	Sakha 3	81.47	82.44	81.96	11.14	11.27	11.21	3.38	3.49	3.44
	Misr 1	74.18	76.55	75.37	9.00	9.39	9.20	2.74	2.91	2.83
Mean		82.76	83.92	83.34	11.34	11.64	11.49	3.44	3.63	3.54
I_4	Nubariya 2	95.97	97.50	96.74	10.56	10.99	10.78	3.35	3.41	3.38
	Giza 716	88.50	89.51	89.01	9.85	10.33	10.09	2.85	3.00	2.93
	Sakha 3	82.71	84.97	83.84	8.22	9.05	8.64	2.50	2.82	2.66
	Misr 1	74.99	76.13	75.56	7.49	7.76	7.63	2.41	2.56	2.49
Mean		85.54	87.03	86.29	9.03	9.53	9.28	2.78	2.95	2.87
General mean of cultivars	Nubariya 2	89.92	90.48	90.20	10.65	11.02	10.84	3.32	3.45	3.39
	Giza 716	84.23	85.73	84.98	11.01	11.60	11.31	3.26	3.48	3.37
	Sakha 3	79.15	80.89	80.02	9.09	9.63	9.36	2.75	2.99	2.87
	Misr 1	71.51	73.60	72.56	7.96	8.27	8.12	2.48	2.60	2.54
LSD 0.05	Irrigation	2.66	2.49	2.15	0.53	0.61	0.45	0.29	0.26	0.28
	cultivars	3.40	2.97	2.86	0.50	0.56	0.40	0.22	0.29	0.25
	Irri. X Cult.	6.80	5.95	5.04	1.01	1.11	0.97	NS	NS	NS

Effect of the interaction

As for the interaction effect between irrigation regimes and faba bean cultivars, results in Tables 5 and 6 show that there were significant interaction effects on all traits under study except straw yield fad^{-1}. The maximum values of pod number $plant^{-1}$, seed number $plant^{-1}$ and seed yield fad^{-1} were obtained from Giza 716 cultivar with water regime (I_3) , but Misr 1 recorded the lowest values for the same traits under water (I_1) regime. As for100- seed weight, Nubariya 2 cultivar attained the highest values with water regime (I_3), but Misr 1 cultivar recorded the lowest values for the same traits under water regime (I_1).

Water Relations

Effect of water deficit on relative water content (RWC), osmatic potential (OP), water consumptive use (WCU) and Water use efficiency (WUE)

Results presented in Table 7 illustrate that water deficit due to application of irrigation regime (I_1) which received one irrigation only resulted in significant reduction of RWC but OP was significantly increased. The highest value of WCU was achieved when plants received irrigation regime (I_4), however the lowest value was obtained under irrigation regime (I_1). As a result of plants exposed to water deficit (I_1) the mean reduction in WCU was 25.00, 25.76 and 30.66 % compared to I_2, I_3 and I_4 respectively. Whereas irrigation regime I_1 and I_3 increased WUE compared to irrigation regimes I_2 and I_4. In this respect **Abid *et al*. (2017)** observed that soil water deficit stress (90% FC) reduced RWC compared with water stress of 50 and 30% field capacity on faba bean plant. Moreover**, Gupta *et al*. (2017)** found that water use efficiency (WUE) decreased with higher irrigation regimes and lowest water use efficiency (WUE) was registered with irrigation treatments I_1 (APE =1.00). It was followed by irrigation regime I_2 (APE =0.75) and I_3 (APE =0.50) in ascending order. This might be due to the fact that the increase in yield was not proportionate to the increase in water consumptive use (WCU).

Faba bean cultivars behavior

Regarding the behavior of faba bean cultivars, results recorded a significant effect on each of RWC, OP and WUE traits (Table 7). It could be observed that Giza 716 cultivar followed by Nubariya 2 cultivar surpassed those of Sakha 3 and Misr 1 cultivars for RWC and WUE, *vice versa* was found in OP. The difference between cultivars for WCU, data revealed that the maximum value of WCU was obtained by Sakha 3 cultivar followed by Giza 716 cultivar, while the minimum value was obtained by Misr 1 cultivar.

Effect of the interaction

For the interaction between irrigation treatments and faba bean cultivars, all faba bean cultivars were affected by water deficit (Table 7). It's clear from results that under water stress (I_1) Nubariya 2 cultivar achieved the highest value for each of RWC and WUE, while recorded the lowest value for each of OP and WCU. In the presence of water abundance (I_3) Giza 716 faba bean cultivar surpassed the others in RWC and WUE. So Nubariya 2 was more tolerant to water deficit followed by Giza 716 cultivar while Sakha 3 and Misr 1 cultivars were more sensitive to drought. These results confirmed by **Subbarao *et al*. (2000)** who found that in some genotypes, RWC was less affected by water deficit due to the accumulation of amino acids and proteins which lowers the osmotic potential of the cells, draws water into the cells and tissues and thus help in the maintenance of turgor, carbon intake and plant growth. **Zhang *et al*. (2012)** cleared that under drought stress, leaf RWC plays an important role in tolerance of plants to stress by inducing osmotic adjustment due to the accumulation of osmoprotectants.

Chemical Analyses

Effect of water deficit on total chlorophyll of leaves, nitrogen, and protein contents

Results presented in Table 8 reveal that water deficit due to application of irrigation regime (I_1) which received one irrigation only resulted in significant reduction of total chlorophyll of leaves, whereas the same irrigation regime (I_1) increased significantly nitrogen, and protein contents compared with I_2, I_3 and I_4 treatments. Faba bean plants under water stress (I_1) resulted in reduction in chlorophyll of leaves by 26.99 % compared with I_3 while, protein content increased by 9.55% compared with I_4 respectively. It may be due to accelerated leaf

Table 7. Water deficit effect on leaf relative water content (RWC %), leaf osmotic potential (OP), water consumptive use (WCU) and water use efficiency (WUE) of four faba bean cultivars in 2017/2018 and 2018/2019 seasons

Irrigation regime	Cultivar	RWC (%)			OP (bar)			WCU (mm)			WUE (kg m^{-3} fad.$^{-1}$)		
		2017/ 2018	2018/ 2019	Comb.	2017/ 2018	2018/ 2019	Comb.	2017/ 2018	2018/ 2019	Comb.	2017/ 2018	2018/ 2019	Comb.
I_1	Nubariya 2	60.92	63.61	62.27	-17.40	-16.40	-16.90	1082	1102	1092	1.42	1.43	1.42
	Giza 716	56.89	59.39	58.14	-19.38	-17.33	-18.36	1101	1130	1116	1.24	1.27	1.25
	Sakha 3	49.57	53.38	51.48	-20.04	-19.51	-19.78	1005	1126	1066	1.16	1.12	1.14
	Misr 1	47.79	51.96	49.88	-22.63	-21.05	-21.84	1100	1103	1102	0.94	1.00	0.97
Mean		53.79	57.08	55.44	-19.86	-18.57	-19.22	1072	1115	1094	1.19	1.21	1.20
I_2	Nubariya 2	68.14	70.03	69.09	-16.42	14.68	-15.55	1421	1452	1437	1.12	1.18	1.15
	Giza 716	74.36	77.35	75.86	-15.14	13.92	-14.53	1436	1489	1463	1.30	1.33	1.31
	Sakha 3	65.84	69.54	67.69	-18.30	17.94	-18.12	1504	1506	1505	0.98	1.04	1.01
	Misr 1	59.95	60.08	60.02	-20.06	19.10	-19.58	1449	1405	1427	0.93	0.97	0.95
Mean		67.07	69.25	68.16	-17.48	-16.41	-16.95	1453	1463	1458	1.08	1.13	1.10
I_3	Nubariya 2	73.03	75.97	74.50	-15.81	-14.27	-15.04	1501	1433	1467	1.23	1.28	1.25
	Giza 716	80.19	82.95	81.57	-14.19	-13.46	-13.83	1470	1506	1488	1.41	1.44	1.42
	Sakha 3	69.71	71.10	70.41	-16.53	-16.34	-16.44	1516	1489	1503	1.14	1.17	1.15
	Misr 1	65.89	65.03	65.46	-18.08	-17.58	-17.83	1466	1403	1435	0.95	1.04	1.00
Mean		72.21	73.76	72.99	-16.15	-15.41	-15.78	1488	1458	1473	1.18	1.23	1.21
I_4	Nubariya 2	67.97	68.47	68.22	-15.95	-15.74	-15.85	1589	1580	1585	1.03	1.08	1.06
	Giza 716	63.16	64.93	64.05	-16.18	-15.91	-16.05	1613	1601	1607	0.95	1.00	0.97
	Sakha 3	54.56	55.09	54.83	-18.83	-17.3	-18.07	1607	1611	1609	0.79	0.87	0.83
	Misr 1	49.33	52.42	50.88	-21.37	-19.86	-20.62	1489	1525	1507	0.78	0.79	0.78
Mean		58.76	60.23	59.50	-18.08	-17.20	-17.64	1575	1579	1577	0.89	0.93	0.91
General mean of cultivars	Nubariya 2	67.52	69.52	68.52	-16.4	-15.27	-15.84	1398	1392	1395	1.18	1.24	1.21
	Giza 716	68.65	71.15	69.90	-16.22	-15.16	-15.69	1405	1431	1418	1.21	1.26	1.24
	Sakha 3	59.92	62.28	61.10	-18.43	-17.77	-18.10	1408	1433	1421	1.00	1.05	1.03
	Misr 1	55.74	57.37	56.56	-20.53	-19.40	-19.97	1376	1359	1368	0.90	0.95	0.92
LSD 0.05	Irrigation	1.92	1.88	1.63	-0.75	-1.10	-0.68	-	-	-	0.07	0.10	0.05
	cultivars	2.68	2.63	2.22	-0.85	-0.71	-0.52	-	-	-	0.06	0.09	0.04
	Irri. X Cult.	5.36	5.26	4.08	-1.70	-1.42	-.1.09	-	-	-	0.13	0.19	0.11

Table 8. Water deficit effect on total chlorophyll of leaves, seed nitrogen (%) and seed protein (%) of four faba bean cultivars in 2017/2018 and 2018/2019 seasons

Irrigation regime	Cultivar	Total chlorophyll 100 DAS (mg m^{-2})			Seed nitrogen (%)			Seed protein (%)		
		2017/ 2018	2018/ 2019	Comb.	2017/ 2018	2018/ 2019	Comb.	2017/ 2018	2018/ 2019	Comb.
I_1	Nubariya 2	17.90	19.48	18.69	4.60	4.78	4.69	28.78	29.87	29.33
	Giza 716	15.21	17.21	16.21	4.51	4.53	4.52	28.22	28.31	28.27
	Sakha 3	14.91	15.75	15.33	4.31	4.41	4.36	26.93	27.59	27.26
	Misr 1	13.31	13.65	13.48	4.09	4.26	4.17	25.54	26.63	26.09
Mean		15.33	16.52	15.93	4.38	4.50	4.44	27.37	28.10	27.74
I_2	Nubariya 2	22.7	23.88	23.29	4.43	4.45	4.44	27.69	27.79	27.74
	Giza 716	23.38	24.26	23.82	4.25	4.38	4.31	26.56	27.35	26.96
	Sakha 3	19.30	20.39	19.85	4.16	4.26	4.21	26.02	26.65	26.34
	Misr 1	15.51	16.49	16.00	4.00	4.06	4.02	24.92	25.37	25.15
Mean		20.22	21.25	20.74	4.21	4.29	4.25	26.30	26.79	26.55
I_3	Nubariya 2	23.55	24.01	23.78	4.31	4.37	4.34	26.96	27.31	27.14
	Giza 716	24.57	25.08	24.83	4.17	4.32	4.25	26.08	26.98	26.53
	Sakha 3	20.40	22.02	21.21	4.07	4.17	4.12	25.46	26.04	25.75
	Misr 1	17.33	17.60	17.47	3.88	4.02	3.95	24.22	25.12	24.67
Mean		21.46	22.18	21.82	4.11	4.22	4.17	25.68	26.36	26.02
I_4	Nubariya 2	18.30	20.11	19.21	4.13	4.15	4.14	25.82	25.91	25.87
	Giza 716	16.57	19.56	18.07	4.03	4.18	4.11	25.20	26.14	25.67
	Sakha 3	15.65	16.88	16.27	3.96	4.10	4.03	24.74	25.66	25.20
	Misr 1	14.83	15.00	14.92	3.75	3.81	3.78	23.43	23.81	23.62
Mean		16.34	17.89	17.12	3.97	4.06	4.02	24.80	25.38	25.09
General mean of cultivars	Nubariya 2	20.61	21.87	21.24	4.37	4.43	4.40	27.31	27.72	27.52
	Giza 716	19.93	21.52	20.73	4.24	4.35	4.30	26.51	27.20	26.86
	Sakha 3	17.57	18.76	18.17	4.13	4.24	4.19	25.79	26.48	26.14
	Misr 1	15.24	15.68	15.46	3.92	4.04	3.98	24.53	25.23	24.88
LSD 0.05	Irrigation	0.90	0.62	0.73	0.08	0.13	0.11	0.51	0.83	0.66
	cultivars	0.71	0.71	0.59	0.10	0.12	0.08	0.63	0.72	0.50
	Irri. X Cult.	1.42	1.41	1.13	0.20	0.20	0.16	1.26	1.25	0.97

senescence, which might have decreased the rate of photo-assimilation (**Matile *et al*., 1999**) or attributed to oxidative damage to the chloroplasts through dilation of the thylakoids, breakdown of the envelope and destabilization of the pigment protein complexes (**Prasad and Saradhi 2004**). Results of this work are in line with the findings of **Ammar *et al.* (2014); Siddiqui *et al*. (2015)** and **Abid *et al*. (2017)** who reported that total chlorophyll content was decreased under water stress irrigation regimes. Also **Gupta *et al*. (2017); Ouzounidou *et al.* (2014) and Mekkei (2014)** found that protein content of faba bean plants under drought stress was increased.

Faba bean cultivars behavior

Results showed significant differences among faba bean cultivars in total chlorophyll of leaves, nitrogen and protein contents of faba bean seeds (Table 8). It could be observed that Nubariya 2 and Giza 716 cultivars recorded the highest value of total chlorophyll of leaves on the contrary the lowest value was obtained by Misr 1cultivar. Nubariya 2 cultivar was significantly surpassed the other cultivars in each of nitrogen and protein contents. These results are agreed with **Mekkei (2014)** who found that under drought stress Giza 3 followed by Nubaria 1 cultivars gave the highest value for each of No. of pods plant^{-1}, 100- seed weight, seed yield plant^{-1}, seed yield fad^{-1} and seed protein content. However, Sakha 3 cultivar gave the lowest value of mentioned traits.

Effect of the interaction

As for the interaction effect between irrigation regimes and faba bean cultivars results in Table 8 show that there were significant effect on total chlorophyll of leaves, nitrogen and protein contents of faba bean seeds. The maximum value of total chlorophyll of leaves was obtained from Giza 716 cultivar with water regime (I_3), but Misr 1 recorded the lowest values for the same traits under water (I_1) regime. As for nitrogen and protein contents of faba bean seeds Nubariya 2 cultivar attained the highest values with water regime (I_1), but Misr 1 recorded the lowest values for the same traits under water regime (I_1).

Conclusion

From the results obtained in this study, it could be concluded that, sowing faba bean plants with applying life irrigation only; such treatment (I_1) save about 29.38 - 34.76% of water consumptive use (WCU) and accept 11.11- 13.02% reduction in seed yield if irrigation water was not enough .It can be recommended to sowing Nubaryia 2 for save irrigation water when water is not available and sowing Giza 716, Sakha 3 and Misr 1 in the presence of water abundance (I_3).

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التقييـــم الفســـيولـــوجـــى لبعض أصـــناف الفـــول البلـــدى تحـــت ظـــروف نقص المياه

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أجريت تجربة حقلية بمحطة البحوث بالجميزة-محافظة الغربية- جمهورية مصر العربية خلال الموسمين المتتاليين ٢٠١٨/٢٠١٧ و ٢٠١٩/٢٠١٨ لتقييم أربعة أصناف من الفول البلدى (نوبارية ٢ ، جيزة ٧١٦ ، سخا ٣ ، مصر ١) تحت ظروف نقص المياه. وتم استحداث نقص الماء برى نباتات الفول البلدى رية واحدة فقط (رية المحاياة) (I_1)، مقارنة بمعاملات الري الاخرى I_2 و I_3 و I_4 التي تلقت ريًا إضافيًا عند فقد ٥٠ % أو ٦٥ % أو ٨٠ % من الماء الميسر بالتربة على التوالي. ويمكن تلخيص النتائج كالاتى: أدى نقص ماء الرى (I_1) الى انخفاض معنوى فى كلا من المادة الجافة ، دليل مساحة الورقة ، معدل نمو المحصول، ارتفاع النبات، عدد فروع/ نبات، عدد القرون/نبات، وزن بذور النبات ، وزن الـ ١٠٠ بذرة ، محصول البذور والقش للفدان والكلوروفيل الكلي للاوراق، في حين زاد الضغط الاسموزى للورقة وكفاءة استخدام الماء ونسبة النيتروجين والبروتين فى البذور، أدى اتباع معاملة الري (I_3) إلى زيادة معنوية في جميع الصفات المذكورة باستثناء الضغط الاسموزى للورقة ونسبة النيتروجين والبروتين فى البذور التى انخفضت معنويا، سجل صنفى نوبارية ٢ وجيزة ٧١٦ أعلى القيم دليل مساحة الاوراق ،للمادة الجافة ، معدل نمو المحصول، عدد الفروع للنبات، وزن البذور للنبات، وكفاءة استخدام الماء ومحتوى الورقة من الكلوروفيل مقارنة بالصنفين سخا ٣ ، مصر ١ ولكن انخفض الضغط الاسموزى للورقة. بالإضافة إلى ذلك ، تفوق صنف نوبارية ٢ بشكل ملحوظ في ارتفاع النبات ووزن ١٠٠ بذرة ونسبة النيتروجين والبروتين فى البذور مقارنة بالأصناف الأخرى ، بينما سجل صنف جيزة ٧١٦ أعلى قيم لصفات عدد قرون النبات ومحصول البذور للفدان مقارنة بالأصناف الأخرى ولكن صنف مصر ١ سجل أدنى القيم للصفات السابقة، كان تأثير التفاعل بين معاملات الري وأصناف الفول معنوياً لجميع الصفات المذكورة فيما عدا عدد الفروع للنبات ومحصول القش للفدان، وكانت اعلى القيم لصفات كل من دليل مساحة الاوراق، للمادة الجافة ، معدل نمو المحصول، عدد القرون للنبات، عدد البذور للنبات ومحصول البذور للفدان والكلوروفيل الكلي للأوراق عند رى الصنف جيزة ٧١٦ برية المحاياة ورية ثانية عند فقد ٦٥% من الماء الميسر، بينما سجل صنف مصر ١ أقل القيم لنفس الصفات السابقة عند الري برية المحاياة فقط، ومن نتائج البحث يمكن التوصية بزراعة صنف نوبارية ٢ مع اضافة رية المحاياة فقط وهذا سيوفر حوالي ٢٩.٣٨ – ٣٤.٧٦% من الاستهلاك المائى مع حدوث انخفاض في محصول البذور للفدان قدره ١١.١١- ١٣.٠٢% إذا لم تكن مياه الري كافية (اجهاد مائى) وزراعة اصناف جيزة ٧١٦ ، سخا ٣ ومصر ١ إذا كانت المياه متوفرة.

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